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SVEN HEDIN

SCIENTIFIC RESULTS

OF A JOURNEY IN

CENTRAL ASIA

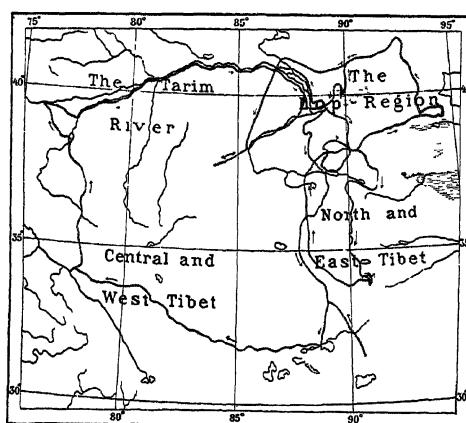
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G E O L O G Y

BY

DR HELGE BÄCKSTRÖM AND HARALD JOHANSSON



STOCKHOLM

LITHOGRAPHIC INSTITUTE OF THE GENERAL STAFF  
OF THE SWEDISH ARMY

STOCKHOLM

KUNGL. BOKTRYCKERIET. P. A. NORSTEDT & SÖNER

1907

# G E O L O G Y

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HELGE BÄCKSTRÖM AND HARALD JOHANSSON.

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Dr. SVEN HEDIN's geological collections from this voyage consist of not less than 800 rock specimens, with few exceptions taken from bed rocks in different places all along his route. Through the kindness of Dr. HEDIN these large collections were presented to the geological department of the University of Stockholm, where they are now deposited, together with the numerous slides for study made from them, and the specimens collected by Dr. HEDIN in the same region in 1896 which previously had also been presented to the University of Stockholm.

The whole material was studied by us, the rocks determined, the descriptive catalogue of the specimens given below worked out, and finally an effort was made to construct a geological map of the area. This map, naturally, could for the most part become nothing more than a geological map of the route, still we hope that it may serve as a skeleton-map to be filled out by future explorations.

The rocks collected are classified on the map as follows:

- Red sandstone series,
- Greywacke series,
- Slate and Phyllite series,
- Gneiss and Mica Schist series,
- Dense Limestone,
- Crystalline Limestone,
- Greenstones and Greenstone-schists.
- Young volcanic rocks,
- Old volcanic rocks,
- Granites and related deep-seated igneous rocks.

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## Red Sandstone series.

The deposits belonging to this series consist of sandstone and sandy slates containing here and there layers of gypsum and also conglomerates. The rocks generally exhibit red or violet colours, although greenish or gray rocks have also been included. According to HEDIN the soils in the sandstone regions are bright red in colour.

The sandstones consist of quartz grains which are generally angular and which are embedded in a matrix very red in colour and generally free from calcite. In this series, however, there have also been included some calcareous, loose, non-metamorphosed sandstones or fine sandy slates usually with grayish colours. (Ex. A: 315—319; B: 113—114.)

The conglomerates are generally very polymict, with well rounded pebbles of dense limestones, dark slates, greenish greywackes or quartz; in several places also of porphyries. (Ex. A: 122; B: 100.)

The sandstones are not dynamo-metamorphic; they have taken part in the formation of the mountain ranges but the dips are often flat. — The series has a considerable extension in Eastern Tibet, probably even greater than the map shows, since the specimens on which the map is based were collected along the route, i. e. in the valleys and passes, and these specimens sometimes consist of other rocks, although, according to HEDIN's description, the surrounding mountains are made up of sandstone. As mentioned above there are also large districts in which the bed rock does not appear although from the reddish colour of the soil it is evident that it is sandstone.

## Greywacke series.

This name has been used for a widely distributed and rather constant type of sedimentary rocks. The rocks in question generally show dark greenish-grey or brownish-green colours and are sometimes finely rust-spotted. They are composed of fragments of quartz, felspar and light mica in a matrix, generally rich in calcite; very often also fragments of black slates and dense limestones are found. The more coarse-grained varieties consist of a lightly weathered granitic material with some detritus of slate (Ex. A: 309, 321, 323, 27, 28). Real conglomerates apparently do not occur. — The most common types are constituted by more fine-grained angular detritus with larger grains of felspar, quartz or mica sprinkled in without marked arrangement or layering. In a few cases the quartz grains predominate, thus producing varieties which have been referred to in the catalogue as greywacke-sandstones and quartzite-sandstones. Besides the greywackes mentioned above in which the grains are distinguishable macroscopically, more fine-grained microclastic rocks, "greywacke-slates" have a wide distribution. They occur, according to the descriptions given by HEDIN in his work on his journey of 1896, in alternate bedding with the coarser varieties. Their color is generally a dark grey, caused by the presence of a carbonaceous pigment. In these greywacke-slates

there may sometimes be seen twig-like accumulations of apparently carbonaceous matter which may possibly be interpreted as being fossil plants. (Ex. A: 312, 112, 170 a. o.) These greywacke-slates are harder than true clay slates and do not show well pronounced slaty cleavage but more uneven fracture. — The clastic structure is microscopically well preserved and the rocks do not show any considerable recrystallisation.

The greywackes are everywhere strongly dislocated, showing steep dips. They show very marked signs of pressure, are very much hardened, often show slickensides as well as fissures filled up with carbonates or quartz. In certain regions they are rich in quartz nodules produced by secretion (Ex. B: 274—276, a, h etc.); most of the numerous quartz and quartzite specimens in the collection probably came from such secretions. In some parts the schistosity is specially developed, thus producing glistening separation planes; the greenish greywackes here pass over into greenish schists with parallel jointing (A: 223, 88 a. o.); the dark greywackes into darkly glistening hard schists, often rust-spotted (Ex. B: 275); the dark more fine-grained greywacke-slates pass over into phyllitic schists which it has probably not been possible to separate from certain phyllites, not belonging to the greywacke series.

Some very much hardened quartzite-sandstones of rather different type have also been mapped as greywacke.

The greywacke series is markedly older than the red sandstones but younger than, at least, part of the schists and limestones; probably also younger than most of the granites.

Representatives for this series have been found over the whole region covered by the route, from the beginning to the end.

### Clay slates and phyllites.

These rocks are found here and there; are, however, wanting in the north-east region, which is comparatively most crystalline. Some of them appear to be geologically related to the dark, dense limestones, others are probably related to the above mentioned greywacke-slates. — The same color has also been used on the map for some specimens of black siliceous schists (Ex. A: 192, 196; B: 41, 74, 75). — In the neighbourhood of Ladak a series of rather varying schists have been mapped as phyllites.

On the border of the great granite regions several examples of contact metamorphism are found, as spotted slates (A: 30) and hornfelses.

### Dense limestones and dolomites.

Of these varying types occur, all of which can probably not be referred to a single geological formation, although most of them appear to be older than not only the red sandstones but also than the greywackes and a good many of the

granites. It is possible to distinguish to a certain extent a series of lighter, purer limestones (with grey, pink, yellowish etc. colors), occasionally with chert concretions (Ex. B: 81, 116, 121), and a series of dark, more impure bituminous limestones, passing over into calcareous clay slates. — Judging from the dips of the strata, the limestones are everywhere dislocated, generally also crushed and filled with calcite veins. Semicrystalline or microcrystalline types are often found. Near the great mass of granite in NE Tibet dark limestones and calcareous clay slates are found, containing small crystals of scapolite and diopside, also lumps of magnetic pyrites (Ex. A: 273, 271), a specimen of more crystalline calcite-diopside-rock (A: 272) also comes from here. These rocks apparently are due to the metamorphic action of the granite.

The limestones are most richly represented in the south eastern parts of the route and there they are also least metamorphosed. From this region there have also been brought several specimens containing remains of fossils. Unfortunately all these traces of fossils are indeterminable, on account of which the most interesting question of the geological age of these Tibetan deposits cannot be solved by this material. But as it appears to be indubitable that the question of the age of the deposits might easily be solved if specimens were collected here with special regard to the fossil remains which they contain, the localities from which we have noted traces of fossils in the limestone-specimens have been marked with a blue F on the map and an enumeration of the localities is here given, which may be of service in future investigations:

A-series:

1900. 13/9 No. 142.

B-series:

1901. 10/7	No. 78	1901. 11/9	No. 124
21/7	89	14/9	125
24/8	96		126
	98	15/9	127
25/8	103	18/9	128
10/9	120	25/9	129—131
11/9	121	10/10	158.

### Crystalline limestones and dolomites.

Some of the crystalline limestones are found in close connection with the dense varieties, others in the more highly metamorphosed districts together with gneisses and mica schists. As dark bituminous veins are sometimes found and also passages into semicrystalline, dark dense limestones, it seems rather probable that the crystalline varieties, genetically considered, are only more intensely metamorphosed facies of the dense varieties. — Special attention must be drawn to the many dolomites found.

## Gneiss and Mica Schist.

In this series have been included various strongly crystalline types of schists: gneisses, granulites, mica schists, hornfels-like rocks etc. The occurrence of such rocks is surprisingly small in view of the region being mountainous; they are completely absent in the southern two thirds of the region covered by the map, and are only found to any extent in the north.

Schistose, gneiss-like granites have been mapped as granites as far as possible.

The gneisses are essentially grey biotite- or biotite-hornblende-bearing types rich in white felspar. Of other types there may be mentioned:

A: 364, 368, 373 = light granulitic rocks.

A: 369, 376 = garnet-bearing gneisses.

B: 19 = pyroxene-gneiss with calcite and scapolite.

Mica schists are rather rare. — A: 370 is a coarse-grained garnet-bearing variety; A: 363 a fine-grained muscovite-chlorite-schist; etc.

In this section there have also been included a series of close-grained, dark grey or violet grey hornfelslike rocks, distinguished by a very strongly coloured red-brown biotite, and in part rather rich in felspar. Some of them seem to be partly recrystallized greywackes, others are evidently crystallized phyllites; these rocks apparently have got their characters by contact-metamorphism from the great masses of granite and their extensions.

## Greenstones and Greenstone-schists.

Diabases, comparatively unaffected by pressure, are sometimes found; in some cases as dykes, in other cases their geological mode of occurrence is not noted. The diabases and connected "greenstones" are, however, in general more or less completely converted into amphibolites or very schistose "greenstone-schists". Especially is this the case in the most north-eastern part of the route, where, on the whole, the metamorphism has been most intense. From here also a few schistose gabbros were brought home.

## Granites.

Granites frequently occur in the north-eastern parts as well as in the district north of Ladak; on the other hand they are lacking in the whole of the southern region. Of the three masses north of Ladak, the most northern and the most southern consist of soda-granites, while the middle one is made up of quartz-dioritic rocks. — In the great granite-region in north-eastern Tibet granites of very varying types occur, strongly modified by pressure as well as comparatively little changed. As mentioned above some of them border upon schists which are evidently contact-metamorphosed and are consequently younger than part of the schist-formation; on the other hand the felspathic material of the greywackes indicates a derivation from older granites.

## Effusive igneous rocks.

It seems possible to carry out in this region the customary division of these rocks into an older and a younger series, the latter characterized by a preserved glassy groundmass as well as by a greater freshness of the constituent minerals. The former has been referred to on the map as "*old volcanic rocks*", the latter as "*young volcanic rocks*".

*Effusive igneous rocks of older type* are found here and there along the route; their principal distribution, however, is in NE Tibet (Nos. A: 51—64, 245—248, 250). Here occurs a rich variety of quartzporphyrytuffs, some composed of the finer detritals and showing the characteristic ash-structure, others are again made up of crystals of quartz and felspar and of angular pieces of quartzporphyries of different types; subordinately also of detritals from dark porphyritic rocks. In the western part of the region, the porphyritic character becomes more accentuated. — The most of these tuffs and associated porphyries do not exhibit marked signs of strain, but on the northern border examples of dynamometamorphic action occur. Such schistose quartz-porphyries or quartz-porphyrites, passing into sericite-schists, are met with on several places along the route.

*Young volcanic rocks* were also met with during HEDIN's previous journey at those points along this his route, which are indicated on the map. The specimens brought home then were studied by one of us.\* This investigation showed that the rocks were a *bronzite-andesite*, characterized by the fact that all the crystallized pyroxene is rhombic, while the monoclinic pyroxene is completely or almost entirely lacking.

To a similar type belong also the specimens collected on the new journey from the localities at  $35^{\circ}$  N. L.,  $89^{\circ}$  E. Gr. (A: 144—152) and  $36^{\circ} 15'$  N. L.,  $88^{\circ} 30'$  E. Gr. (B: 46); still varieties which besides the dominating bronzite contain not inconsiderable quantities of monoclinic pyroxene were also found here.

An interesting holocrystalline variety of this type of rock occurs between Naktsong-tso and Selling-tso, the most southern point on HEDIN's route (B: 123). Macroscopically examined the rock shows a close-grained violet-brown groundmass with small phenocrysts of fresh and glistening pyroxene. This pyroxene seen under the microscope is found to be exclusively rhombic bronzite; only on the borders of the larger crystals, as well as here and there among the pyroxenes of the groundmass, the bright interference colours indicate the presence of small quantities of monoclinic pyroxene. Associated with the bronzite and distinctly younger than this, brown biotite occurs, but never as phenocrysts. The groundmass consists — excepting rhombic and some monoclinic pyroxene, biotite, ores etc. — essentially of lathshaped plagioclase with almost trachyoidal appearance. — About the mode of occurrence of this rock nothing is said in HEDIN's notes.

\* H. BACKSTRÖM, Über jungvulkanische Eruptivgesteine aus Tibet. Petermanns Mittheilungen, Ergänzungsheft 131, p. 375 (1900).

From  $35^{\circ} 25'$  N. L.,  $90^{\circ}$  E. Gr. a different type was brought home (A: 107): an andesite rich in phenocrysts of plagioclase and a dark mineral, now totally decomposed to greenish blue hornblende and chlorite. This rock formed two small conical knobs (Scientific Results III p. 103).

At Camp XLV ( $34^{\circ} 40'$  N. L.,  $89^{\circ} 50'$  E. Gr.) there occurs a dark biotite-bearing hornblende-andesite, quite undecomposed and with glassy groundmass; another specimen shows the same rock weathered and with lighter colour (A: 130, 131).

No. A: 121 ( $34^{\circ} 45'$  N. L.,  $90^{\circ} 20'$  E. Gr.), a hard, violet-black rock (Scientific Results III p. 129) is a rather weathered holocrystalline trachytoidic andesite; A: 126 ( $34^{\circ} 45'$  N. L.,  $90^{\circ}$  E. Gr.) a hard and compact andesitic tuff. — No. A: 135 ( $34^{\circ} 35'$  N. L.,  $89^{\circ} 35'$  E. Gr.) is a compact, somewhat weathered hornblende-andesite of a different type.

At  $31^{\circ} 40'$  N. L.,  $86^{\circ} 49'$  E. Gr. LITTLEDALE (*vide* footnote on next page) had reported a volcano called "Tongo", which HEDIN visited on Oct. 4th 1901 and declared not to be a volcano (Sc. Res. IV p. 125—131). He found there as bed rocks a conglomerate, belonging to the red sandstone series, and weathered diabases; he also collected some boulders, apparently derived from the upper parts of the mountain. Among these there are weathered porphyrites, light yellow or white, compact, holocrystalline-granophyric, evidently rather young rocks, and finally also "a kind of light green porphyry or granite", which showed itself to be a rather weathered hornblende-andesite.

Outside eastern Tibet young volcanic rocks have been brought home from the shore of Oman-tso ( $32^{\circ} 25'$  N. L.,  $82^{\circ} 45'$  E. Gr.; Scientific Results IV p. 196; Number of specimens: B: 179—187.) — Some of the rocks from here are rhyolitic tuffs, which, according to HEDIN's diary, show very distinct bedding; the rock "shows long, red, sharply defined edges, jutting out of the detritus on the southern flank of the mountains". — Under the microscope these tuffs show the characteristic ash-structure admirably well developed. Except as tuffs rhyolites do not seem to occur here; on the other hand several specimens consist of hard compact trachytes. They are violet-grey or red, sometimes with secretions of agate, and show under the microscope phenocrysts of biotite and an anorthoclasic felspar in a groundmass with trachyoidal structure.

Far up in the north-east, between Camps CXLI and II, there is a small district of rather weathered but apparently not very old volcanic rocks, partly basic andesites, partly trachytes. (A: 412 etc.)

About the date of the volcanic activity in these regions some words may here be said. The specimens collected during the previous journey as well as those from the two localities first mentioned above (A: 144 etc. and B: 46) HEDIN has called "tuffs", while the other more compact rocks have received various names not indicating a comparatively recent volcanic origin. The short descriptions of their occurrence given in HEDIN's diary never give any indication, suggesting volcanoes with their form still preserved (but compare A: 107). HEDIN also repeatedly tells us that he never has seen a true volcano here. As however the petrographical examination of the rocks collected shows volcanic rocks of modern types to occur here, the conclusion must be drawn, that the volcanic activity that produced them is not

of quite recent date and that therefore the erosion has had time enough to destroy the form of the originally existing volcanoes. On the other hand BONVALOT<sup>1</sup> as well as LITTLEDALE<sup>2</sup> positively say that they have seen volcanoes in these same regions although only at a distance. LITTLEDALE tells us for instance: "On climbing a ridge to the south — I saw in front seven extinct volcanoes; three were small, but four of them were grand fellows" (p. 461) and: "Between 36° 50' and 33° 50' N. L. (and 87°—88° East Gr.) our path lay through a very volcanic region, numerous undoubted volcanoes being visible" (p. 464). — It appears desirable, that future expeditions to these parts of Eastern Tibet, in spite of the enormous difficulties arising from the inhospitable nature of the country, should nevertheless find time to investigate some of these supposed volcanoes.

## Catalogue of the specimens.

### A. From June 1900 to March 1901.

1900.	1900.
3/7 1. Greenstone-schist.	8/7 23. Dolomite, dark, close-grained.
2. Slate, black, hard, calcareous.	24. Limestone, dark, impure, close-grained.
3. Granite, quartz-monzonitic.	25. " " " " "
4/7 3. Dolomite, crystalline, brownish-grey.	9/7 26. Granite, grey fine-grained.
5. Slate, black, phyllitic.	27. Greywacke, coarse-grained and fine-grained.
6. " " " " " , calcareous.	28. Greywacke with fragments of black slate.
7. " " " " " "	29. Dynamometamorphic greenstone.
8. Granite, red, medium-grained.	13/7 30. Dark, contact-metamorphosized, spotted slate.
9. Calcedony-dolomite-rock, brecciated, reddish.	31. Granite, lightly red, rather coarse-grained.
10. Greenstone-schist (dynamometamorphic diabase?).	32. Aplitic, as dykes in granite.
II. " " " " "	17/7 33. Hornblende-gneiss (containing dykes and veins of red granite).
12. Black siliceous schist.	34. Boulder of somewhat crushed plagioclase-granite.
13. Greenstone-schist = 10.	20/7 35. Coarse red granite.
14. " "	36. Dark, hard hornfels, connected with the granites 35 and 37.
5/7 15. Quartz-felspar-rock, quite crushed.	37. Coarse red granite = 35.
16. Quartz-diorite, schistose.	38. Limestone, dense, dark.
17. Vein-quartz.	39. Granite, greenish, schistose.
6/7 18. Granite, dynamometamorphic.	
19. Black, hard, phyllitic slate.	
20. Dark " " " " " wrinkled up.	
21. " " " " " "	
8/7 22. Calcite (from veins).	

<sup>1</sup> GABRIEL BONVALOT, De Paris à Tonkin à travers le Tibet inconnu. Paris 1892, p. 188 and the following.

<sup>2</sup> ST. GEORGE R. LITTLEDALE, A journey across Tibet, from North to South and West to Ladak. (The Geographical Journal Vol. VII No. 5. May 1896.)

1900.

40. Granite, very schistose.  
 41. Greywacke, schistose.  
 22/7 42. » »  
 43. Hornblendic granite.  
 23/7 44. » »  
 45. Greywacke-slate, phyllitic.  
 23/7 46. Greywacke, schistose.  
 47. Granite, coarse-grained, light, with two micas.  
 24/7 48. Granite, fine-grained, grey, with two micas, schistose.  
 49. Gneissic granite, connected with 50.  
 50. Granite, coarse, grey.  
 51. Quartzporphyry, schistose.  
 52 a). Quartzporphyry-tuff, schistose.  
 b). Granite = type 49 or 50, schistose.  
 53. Quartzporphyry-tuff, very fresh, light-yellow with veins of limonite.  
 54. Quartzporphyry-tuff, light, compact.  
 55. Porphyry or -tuff, much weathered.  
 25/7 56. Diabase-porphyrite, fine-grained, weathered; dyke.  
 57. Quartz-porphyrity-tuff.  
 58. »  
 59. »  
 60. »  
 61. »  
 26/7 62. »  
 63. Granite, granophytic, with idiomorphic quartz, unaltered, reddish.  
 64. Quartzporphyrite-tuff, greenish grey, weathered.  
 31/7 65. Granite, coarse-grained, grey.  
 66. » medium-grained.  
 67. » = 65.  
 1/8 68. » medium-grained, with two micas.  
 69. Hornfels, rich in biotite, = 207 and 219.  
 70. Granite = 65.  
 3/8 71. Phyllite.  
 72. Sandstone, brownish-red, somewhat schistose.  
 73. Phyllite.  
 74. Greenstone-schist, probably altered diabase or tuff belonging to the phyllite series.  
 75. Limestone, dark-grey, dense.  
 76. » » »  
 77. » » »  
 78. Greenstone, porphyritic, very fine-grained, epidotized.

1900.

4/8 79 a). Greywacke, dark.  
 b). Greywacke-slate, dark, phyllitic.  
 80. Boulders of weathered greywackes.  
 5/8 81. Greywacke-slate, dark.  
 82. Greywacke, comparatively coarse-grained.  
 6/8 83. » schistose.  
 84. » »  
 85. » »  
 86. » »  
 8/8 87. » whitened.  
 88. » » »  
 89 a). Phyllite, dark-grey.  
 b). Greywacke, schistose, whitened.  
 90. » » »  
 91 a). » » »  
 b). Quartzite, rich in calcite, yellow-white, in alternate bedding with a.  
 9/8 92. Vein-quartz.  
 93. Greywacke.  
 94. Volcanic slag, probably andesitic;  
 95. boulders.  
 12/8 96. Gypsum.  
 14/8 97. Greywacke.  
 98. Greywacke-slate, dark.  
 17/8 99. Clay slate, black, phyllitic.  
 100. Greywacke, greywacke-slate and vein-quartz.  
 101. Greywacke.  
 102. Conglomerate.  
 103 a). Red sandstone.  
 b). Conglomerate.  
 104. Gypsum.  
 19/8 105. »  
 106. Greywacke, yellow-brown.  
 20/8 107. Hornblende-andesite.  
 108. Dolomite, finely crystalline, yellow; as boulders.  
 22/8 109. Salt.  
 110. = 108, with concentric shell arrangement on a large scale.  
 25/8 111. Greywacke.  
 112. Greywacke-slate with accumulations of carbonaceous matter.  
 27/8 113. Sandstone, light.  
 114. Red sandstone, conglomeratic.  
 115. » , more fine-grained.  
 28/8 116. Limestone, dense, grey (boulder).  
 117. » » »  
 30/8 118. » » »  
 31/8 119. Porphyrite, weathered, probably dyke.

1900.

3<sup>1</sup>/8 120. Sandstone = 113.  
121. Andesite, weathered.  
122. Red conglomerate.  
1<sup>2</sup>, 9 123. Red sandstone.  
2<sup>1</sup>, 9 124. »  
3<sup>1</sup>, 9 125. Limestone, dense, grey.  
126. Andesite-tuff, hard and compact.  
127. Red sandstone.  
128. Flint, as boulders.  
129. Windworn black stone.  
8<sup>1</sup>, 9 130. Hornblende-andesite, biotite-bearing; fresh and weathered specimens.  
9<sup>1</sup>, 9 131. Sandstone, greenish.  
132. Red sandstone.  
10<sup>1</sup>, 9 133. Limestone, dense, dark, bituminous.  
134. » » » »  
135. Hornblende-andesite.  
136. Limestone, dense, dark, bituminous.  
137. » » » »  
11<sup>1</sup>, 9 138. Sandstone, greenish-grey, = 131.  
139. Limestone, dense, dark, bituminous.  
13<sup>1</sup>, 9 140. Conglomerate. (As numerous boulders.)  
141. Red sandstone.  
142. Limestone with fossils (?)  
143. Greywacke.  
15<sup>1</sup>, 9 144. Bronzite-andesite, sluggy, as numerous boulders.  
17<sup>1</sup>, 9 145. » compact, as bed rock.  
146. » = 144, boulders.  
147. » compact with some vesicules; as bed rock.  
148. » = 144, boulders.  
149. » = » »  
150. » = » »  
151. » = » »  
152. » compact, as bed rock.  
153. Greywacke-sandstone.  
154. Greywacke, comparatively coarse-grained.  
155. Greywacke-sandstone = 153.  
19<sup>1</sup>, 9 156. Limestone, dense, grey.  
20<sup>1</sup>, 9 157. Greywacke-sandstone, schistose.  
158. Quartzite-sandstone, greyish-white.  
159. » »  
24<sup>1</sup>, 9 160. Red sandstone.  
161. Conglomerate.  
25<sup>1</sup>, 9 162. Red sandstone, very fine-grained.

1900.

25<sup>1</sup>, 9 163. Gypsum.  
164. »  
165. Greywacke-sandstone.  
166. Greywacke-slate, dark.  
167. Limestone, dense, yellow-white.  
168. Greywacke-slate, dark.  
27<sup>1</sup>, 9 169. Porphyry, somewhat schistose and much weathered.  
170. Greywacke-slate, close-grained, dark, with glistening accumulations of carbonaceous matter.  
171. Greywacke-sandstone.  
172. Greywacke.  
173. Conglomerate (belonging to the greywacke-series?).  
174. Greywacke.  
175. »  
176. Vein-quartz.  
28<sup>1</sup>, 9 177. Limestone, crystalline, black.  
178. Quartz-porphyry, rich in phenocrysts, red.  
179. Quartz-porphyry, rich in phenocrysts, grey.  
180. Quartz-porphyry, rich in phenocrysts, red, weathered.  
181. Granite-porphyry, granophyric, grey, connected with the preceding.  
182. Red sandstone.  
183. Greywacke.  
184. »  
185. Greywacke-slate, dark, with carbonaceous accumulations. In alternate bedding.  
186. Clay-slate, soft, black.  
187. Greywacke-sandstone.  
30<sup>1</sup>, 9 188. »  
189. Breccia of greywacke and dark limestone.  
190. Greywacke.  
1<sup>1</sup>, 10 191. Red sandstone.  
2<sup>1</sup>, 10 192. Siliceous schist (= B: 41).  
193. Greywacke-slate, phyllitic.  
3<sup>1</sup>, 10 194. Greywacke-sandstone with vein of quartz.  
195. Limestone, dense, with dark crystals of calcite.  
196. Phyllite.  
4<sup>1</sup>, 10 197. Limestone, schistose, semicrystalline, light.  
5<sup>1</sup>, 10 198. Conglomerate.  
6<sup>1</sup>, 10 199. Greywacke.

## 1900.

200. Conglomerate = 198, connected with:  
 201. Calcareous sandstone, fine-grained, light (Greywacke-series?).  
 202. Granite, like 215; boulder.  
 203. Weathered porphyry-tuff?  
 204. Syenite-porphyry.  
<sup>6/10</sup> 205. Weathered tuff = 203?  
<sup>7/10</sup> 206. Granite, fine-grained, red, as boulders.  
 207. Hornfels (?).  
 208. Granite, coarse-grained, with perthitic felspar.  
<sup>8/10</sup> 209. Granite, fine-grained, with two micas, grey.  
 210. Mica schist, boulder.  
 211. Quartzporphyrite.  
 212. Porphyrite, dark, close-grained.  
 213. Quartzporphyrite-tuff (boulder).  
 214. »  
 215. Granite, medium-grained, reddish, not affected by pressure.  
 216. Granite, medium-grained, reddish, not affected by pressure.  
 217. Granite, = 215 and 216 with aplitic vein.  
 218. Greywacke.  
 219. »  
<sup>9/10</sup> 220. »  
 221. »  
 222. »  
 223. Clay slate, subordinate layers in 222.  
<sup>10/10</sup> 224. Greywacke.  
 225. »  
 226. » . , schistose.  
<sup>11/10</sup> 227 a). » » , almost phyllitic.  
     b). Quartz-epidote-amphibolite.  
<sup>13/10</sup> 228. Granite with felspar eyes, grey.  
 229. Diabase.  
 230. Granite-gneiss, red (boulders).  
 231. Pegmatite. »  
 232. Gneiss, fine-grained, rich in mica.  
<sup>17/10</sup> 233. Granite = 228, intruded in:  
 234. Mica schist.  
 235. Granite, medium-grained, red.  
 236. Granite = 235, vein in red gneiss. (Boulders.)  
 237. Granite = 233. (Boulders.)  
<sup>19/10</sup> 238. Green chloritic schist.

## 1900.

<sup>20/10</sup> 239. Quartzite, bluish white.  
<sup>6/11\*</sup> 240. Granite, light, somewhat schistose.  
 241. » » »  
 242. » , gneissic, grey.  
 243. » » »  
 244. Greywacke.  
 245. Quartz-porphyrite-tuff.  
<sup>6/11</sup> 246. »  
 247. »  
 248. »  
 249. Greywacke-slate.  
 250. Quartz-porphyrite-tuff, containing also fragments of dark schists.  
 251. Dolomite, crystalline, white.  
 252. » » »  
 253. Mica schist, coarse.  
 254. Quartz-diorite, fine-grained, somewhat schistose.  
 255. Granite, gneissic, red.  
 256. Dolomite, crystalline, white.  
 257. Greywacke, schistose.  
 258. Limestone, impure, semicrystalline.  
 259. » , schistose.  
 260. » »  
 261. Granite, dark, rich in hornblende.  
 262. Diorite.  
 263. Diorite, fine-grained.  
 264. » »  
 265. Granite, greenish, crushed.  
<sup>11/11</sup> 266. » medium-grained, reddish.  
<sup>12/11</sup> 267. » » . , light.  
 268. » » , » reddish; rich in microcline, poor in dark minerals.  
 269. Diorite, fine-grained = 264.  
 270. Quartz-diorite, fine-grained, fresh.  
 271. Limestone, impure, dark; with scapolite and diopside.  
 272. Calcite-diopside-rock, fine-grained, white.  
 273. Limestone, dark = 271.  
 274. » black, schistose.  
<sup>13/11</sup> 275. Granite, reddish, medium-grained, with mortar-structure.  
 276. Granite, reddish, coarse-grained.  
<sup>14/11</sup> 277. » grey, schistose.  
 278. » » »  
 279. » » »

1900.

- <sup>15</sup> 280. Granite, grey, schistose.
- 281. Granite, red, medium-grained, without strain-phenomena, with perthitic felspar.
- 282. Diabase-porphyrite, numerous dykes in:
- 283. Granite = 281.
- 284. Vein-quartz.
- <sup>22</sup> 285. Amphibolite, fine-grained.
- <sup>22</sup> 286. Granite, coarse-grained.
- 287. » »
- <sup>23</sup> 288. » »
- 289. Granite, medium-grained, not crushed; with felspar eyes.
- 290. Granite, medium-grained, not crushed.
- 291. Granite, medium-grained, with two micas, reddish.
- 292. Hornfels, dark, rich in brown biotite; perhaps altered greywacke.
- <sup>29</sup> 293. Granite, grey.
- 294. Red sandstone.
- 295. Granite, schistose, greenish.
- 296. » , medium-grained, grey.
- 297. Limestone, dark, semicrystalline.
- 298. Granite, lenticular, very schistose.
- 299. Sericite-schist, perhaps variety of the preceding.
- <sup>30</sup> 300. Dolomite-marble, reddish-white.
- 301. » »
- 302. Mica schist, calcite- and tourmaline-bearing.
- 303. Mica schist, gneissic.
- <sup>3</sup> 304. » »
- 305. » » , light.
- <sup>3</sup> 306. Dolomite-marble, red and white.
- 307. » pure white.
- 308. Greywacke, dark, fine-grained.
- 309. Greywacke, light, coarse-grained, of granitic and dark schist-material.
- <sup>4</sup> 310. Greywacke = 308.
- 311. Greywacke-slate, dark.
- 312. » » .
- 313. » »
- <sup>13</sup> 314. Limestone, dark grey, porous.
- <sup>17</sup> 315. Sandstone, yellowish, carbonaceous, soft.
- 316. Sandstone, yellowish, carbonaceous, soft.
- 317. Sandstone, yellowish, carbonaceous, very soft.

1900.

- <sup>18</sup> <sub>12</sub> 318 Sandstone, yellowish, carbonaceous, very soft.
- 319. Sandstone, yellowish, carbonaceous, hard, as boulder.
- <sup>20</sup> <sub>12</sub> 320. Granite, crushed and weathered.
- 321. » » »
- <sup>22</sup> <sub>12</sub> 322. Amphibolite.
- 323. Greywacke, granite-like, = 309.
- 324. Greenstone.
- <sup>23</sup> <sub>12</sub> 325. Gypsum, crystals.
- <sup>25</sup> <sub>12</sub> 326. Sandstone.
- 327. Granite, quartz-monzonitic.
- 328. Greywacke, brown, comparatively coarse.
- <sup>29</sup> <sub>12</sub> 329. Greywacke, schistose.
- 330. » » »
- 331. » » »
- 332. Granite, red, poor in dark minerals.
- <sup>30</sup> <sub>12</sub> 333. Limestone, dense, dark.
- 334. » , dense, light with dark streaks.
- <sup>31</sup> <sub>12</sub> 335. » , impure, schistose, dark.
- 336. » = 333.

1901.

- <sup>1</sup> <sub>1</sub> 337. Gabbro, schistose.
- 338. Limestone, dense, dark grey.
- <sup>3</sup> <sub>1</sub> 339. Actinolite-schist, close-grained.
- 340. Limestone, crystalline, with dark streaks.
- 341. Quartz-tourmaline-sericite-schist.
- <sup>4</sup> <sub>1</sub> 342. Greenstone-schist.
- 343. » , with calcite veins.
- 344. Gabbro with light coloured vein, schistose.
- 345. Limestone, crystalline, white.
- 346. Granite, crushed and weathered.
- 347. Limestone, crystalline, with graphite veins.
- 348. Quartz-lens from mica schist.
- 349. Sericite-schist.
- 350. Serpentine, yellow-green; as boulder.
- <sup>5</sup> <sub>1</sub> 351. Granite, fine-grained, grey, schistose.
- 352. Gneiss, fine-grained, grey.
- 353. Vein-quartz.
- 354. Gneiss, banded.
- 355. Granite-gneiss, hornblendic, very schistose, grey.
- <sup>6</sup> <sub>1</sub> 356. Granite-gneiss, hornblendic, very schistose, grey.
- <sup>12</sup> <sub>1</sub> 357. Dolomite-marble.

1901.

358. Greenstone, porphyritic, dark, decomposed; with dolomite-veins.  
 359. Granite, medium-grained, grey.  
 360. Gneiss, lenticular, grey.  
 361. Amphibolite.  
 362. " = schistose gabbro?  
 363. Muscovite-chlorite-schist.  
 364. Gneiss, close-grained, grey.  
 365. Amphibolite.  
 366. Gneiss, very rich in hornblende.  
 367. " "  
 368. Granulite, yellow-white.  
 369. Gneiss, garnet-bearing.  
 370. Mica schist, garnet-bearing.  
 371. Zoisite-quartz-rock, white.  
 372. Quartz-amphibolite.  
 373. Granulite, greyish white.  
 374. Vein-quartz.  
 375. Granite-gneiss.  
 376. Gneiss, dark, garnet-bearing.  
 377. Dolomite-marble.  
 378. Missing.  
 379. Dolomite-marble.  
 380. Quartzite.  
 381. Calcedony-dolomite-rock.  
 382. Granite in contact with kersantite.  
 383. " " "  
 384. Granite-gneiss.  
 385. "  
 386. "  
 387. "  
 388. "  
 389. "  
 390. "  
 391. "  
 392. "  
 393. "  
 394. "  
 395. Granite, coarse-grained, reddish.  
 396. Limestone, crystalline, white.  
 397. Granite-gneiss.  
 398 to } Wind-worn stones from the desert.  
 408. "  
 409. Salt, impure, porous.  
 410. Wind-worn stone.  
 411. " "  
 412. Andesite or porphyrite, basic, weathered.  
 413. = 412.

1901.

414. Aplitic granite, red, fine-grained, weathered.  
 415. = 412.  
 416. = 412.  
 417. Trachyte or syenite-porphyry, dense, red, with trachytic structure, somewhat weathered.  
 418. = 412.  
 419. = 412.  
 420. Siliceous schist, dense, dark.  
 421. Quartz-diabase, medium-grained, showing beginning uralitization.  
 422. Granophyre.  
 423. Granite, red.  
 424. Hornblende-schist.  
 425. Granite or aplite, white, schistose.  
 426. " " "  
 427. Hornblende-schist.  
 428. "  
 429. Gabbro, schistose.  
 430. Limestone, semicrystalline, grey.  
 431. Greywacke, quartztic.  
 432. Granite, grey.  
 433. " , red, even-grained, with dykes of:  
 434. Diabase, close-grained.  
 435. Limestone, crystalline.  
 436. " "  
 437. " "  
 438. Amphibolite as dykes, apparently transformed diabase.  
 439. Granite-gneiss, grey, schistose.  
 440. Amphibolite, very schistose.  
 441. Limestone, finely crystalline, red.  
 442. Amphibolite, very schistose.  
 443. Limestone, crystalline, white.  
 444. Limestone, crystalline, white, with dark streaks.  
 445. Greenstone-schist.  
 446. Chlorite-schist, calcareous, soft.  
 447. Granite-gneiss, dark.  
 448. " light.  
 449. Limestone, crystalline, white.  
 450. Hornfels or close-grained gneiss, rich in brown biotite.  
 451. Granite, grey.  
 452. " red.  
 453. " dark, schistose.  
 454. " red.  
 455. Diabase, transformed into amphibolite.

1901.

<sup>16/3</sup> 456. Granite, crushed, rich in epidote.  
 457. = 455.  
 458. Quartzite.  
 459. Gypsum, crystallized.  
<sup>17/2</sup> 460. Limestone, finely crystalline, schistose, light.  
<sup>18/2</sup> 461. Diabase.  
 462. Dolomite, crystalline, grey.  
 463. » » »

1901.

<sup>18/2</sup> 464. Limestone = 460.  
 465. Greywacke.  
 466. »  
<sup>23/2</sup> 467. »  
 468. Limestone, schistose, dense, yellow; boulder.  
<sup>24/2</sup> 469. Greywacke.  
<sup>1/3</sup> 470. »  
 471. »

## B. From May to December 1901.

1901.

<sup>18/5</sup> 1. Gneiss with pegmatitic veins.  
 2. Gneiss, fine-grained, rich in biotite.  
 3 a). » » »  
 b). Dolomite.  
 4. Gneiss = 2.  
 5. Dolomite, white, coarsely crystalline.  
 6. Granite-gneiss, light.  
<sup>20/5</sup> 7. Limestone, grey, soft, fine-grained.  
 8. Granite, light, very schistose.  
 9. » » »  
<sup>21/5</sup> 10. » » »  
 11. » » »  
 12. » pegmatitic, less schistose.  
 13. » light, schistose.  
<sup>22/5</sup> 14. Gneiss, fine-grained, hornblende-bearing.  
 15. » » »  
 16. » » »  
<sup>23/5</sup> 17. Pegmatitic nodule.  
 18. Granite-gneiss, grey, rich in plagioclase.  
 19. Pyroxene-gneiss with scapolite and calcite.  
 20. Granite, red, coarsely crystalline.  
 21. Gneiss = 18.  
 22. Quartz, apparently from veins.  
 23. Granite, red, syenitic.  
<sup>25/5</sup> 24. Limestone with fragments of quartzitic rocks.  
 25. Gneiss = 2, rich in plagioclase.  
 26. Gneiss = 2.  
<sup>27/5</sup> 27. Dolomite, dark, fine-grained.  
 28. Gneiss, grey, = 26 etc.  
<sup>28/5</sup> 29. Red sandstone.  
<sup>30/5</sup> 30. Mica schist, rich in tourmaline (conf. A: 341).  
 31. Quartzite.

1901.

<sup>1/6</sup> 32. Sericite-schist, light green.  
 33. Gneiss, with strongly developed schistosity.  
<sup>6/6</sup> 34. Gypsum.  
 35. »  
 36. Sandstone, soft, yellow.  
<sup>8/6</sup> 37. Missing; "red clay" according to the diary.  
<sup>10/6</sup> 38. »  
<sup>12/6</sup> 39. Sandstone.  
<sup>14/6</sup> 40. Greywacke-slate, green, schistose.  
<sup>17/6</sup> 41. Siliceous schist (= A: 192).  
<sup>18/6</sup> 42. Limestone, light-grey, fine-grained.  
 43. Greywacke.  
<sup>23/6</sup> 44. »  
 45. »  
<sup>24/6</sup> 46. Bronzite-andesite, vesicular.  
 47. Crystals of quartz, as boulders.  
<sup>25/6</sup> 48. Greywacke.  
 49. »  
 50. Vein-quartz.  
 51. Groupe of aragonite needles, radially arranged.  
<sup>26/6</sup> 52. Greywacke-sandstone.  
<sup>28/6</sup> 53. »  
 54. »  
 55. Hard siliceous concretions.  
<sup>29/6</sup> 56. Diorite-porphyrite, much weathered.  
 57. Greywacke.  
 58. Black slate.  
 59. Quartz-crystal (boulder).  
<sup>30/6</sup> 60. Gypsum.  
 61. Greywacke.  
<sup>1/7</sup> 62. »  
 63. Gypsum, crystallized ("in enormous boulders").  
 64. Greywacke.  
 65. Black slate (= 58).

1901.		1901.
1/7	66. Red conglomerate.	28/8 104. Greywacke-sandstone, hard, greyish-brown.
	67. » »	29/8 105.
	68. Gypsum.	106.   Limestone, dark, dense, bituminous.
2/7	69. Red sandstone.	107.
	70. » »	108.
4/7	71. Phyllite.	2/9 109. Calcareous sandstone, brick-red, loose, comparatively coarse-grained.
	72. Quartzite-sandstone, grey (= A: 158).	110. Limestone, grey, dense.
	73. Greenstone-schist, alternating with:	111. » yellow-white.
7/7	74. Siliceous schist, dense, black, with calcite veins.	3/9 112. Greywacke.
8/7	75. » calcite veins.	4/9 113. Greenish-grey sandstone, marly, soft.
9/7	76. Oolithic calcareous sandstone.	114. » » » » »
10/7	77. Limestone, dense, grey.	5/9 115. Sandstone, brownish-grey.
	78. Limestone (with fossils?).	7/9 116. Limestone, grey, dense, with chert.
	79. Violet-red sandstone.	8/9 117. » » » » »
	80. Limestone, dense, dark, with white veins.	118. Red sandstone.
11/7	81. Fragments of hard siliceous chert with etchings. (Boulders.)	119. Conglomerate.
	82. Conglomerate with gypsum on cavities.	120. Limestone, light, dense, fossiliferous,
12/7	83. Limestone, dark, bituminous.	121.   with chert.
	84. » » »	122. Sandstone.
13/7	85. » » »	123. Bronzite-andesite, holocrystalline.
14/7	86. Porous calcareous rock.	124.
	87. Sandstone, light-grey.	125.
15/7	88. Magnetic iron ore, porous, as boulders.	126.   Limestone, light-grey, dense, apparently fossiliferous.
21/7	89. Limestone, dark, bituminous (with fossils?).	127.
	90. Limestone, dark, bituminous.	128.
	91. Calcareous slate.	129 a.
	92. Limestone, dark.	129 b.   Limestone-conglomerate.
22/7	93. Calcareous slate = 91.	130.   Limestone, light-grey, dense, with fossils.
	94. Conglomerate with fragments of slate (= 101).	132. Red sandstone.
24/8 *	95. Quartz-porphyrite-tuff, rather weathered, but without signs of strain and therefore perhaps "young volcanic". (Boulders.)	133. »
	96. Limestone, dark-grey, with fossils.	28/9 134. »
	97. Greywacke-slate.	29/9 135. Limestone, light, dense.
	98. Limestone with fossils.	2/10 136. » » »
	99. Sandstone.	3/10 137. » » »
	100. Red conglomerate.	138. » » »
	101. Green sandstone with pebbles of limestone and black slate.	4/10 139. Conglomerate, red, = 119.
25/8	102. Sandstone.	140. Conglomerate (= 94).
	103. Limestone, dark, with fossils.	141. Diabase.

\* The dash for Lhasa. Scientific Results III p. 499—525.

1901.

- 4/10 147. Like 144 and 145. (Boulder.)
- 148. Quartzite-sandstone = 168. (Boulder.)
- 149. Like 144, 145 and 147, weathered.
- 150. (Boulder.)
- 151. Diabase. (Boulder.)
- 152. Weathered calcareous rock.
- 153. Hornblende-andesite, holocrystalline, somewhat weathered. (Boulder.)
- 5/10 154. Porphyrite, much weathered.
- 155. » » »
- 7/10 156. Quartz, white, granular, probably from veins.
- 8/10 157. Black phyllite.
- 10/10 158. Limestone, grey, dense, with fossils?
- 159. » » »
- 11/10 160. Limestone, yellowish white, finely crystalline.
- 161. Limestone, yellowish white, dense, brecciated.
- 162. Limestone, yellowish white, dense, brecciated.
- 163. Limestone, yellowish white, dense, brecciated.
- 164. Limestone, yellowish white, dense, brecciated.
- 165. Greywacke, fine-grained.
- 166. Calc-sinter, apparently recent.
- 20/10 167. Conglomerate, calcareous, probably recent.
- 168. Quartzite-sandstone = 148.
- 21/10 169. Limestone, white, finely crystalline.
- 170. Greywacke, dark, fine-grained.
- 171. » » »
- 22/10 172. Dolomite, dense, yellowish white.
- 23/10 173. Quartzite-sandstone.
- 174. »
- 24/10 175. Diabase, probably dyke in the following.
- 176. Limestone, white, dense.
- 25/10 177. » pink, finely crystalline.
- 26/10 178. » yellowish-grey, dense.
- 27/10 179. Rhyolite-tuff, hard, compact.
- 180. Trachyte.
- 181. »
- 182. Rhyolite-tuff.
- 183. Trachyte with veins of agate.
- 184. »
- 185. = 183.
- 186. Rhyolite-tuff, hard, compact.
- 187. » » »
- 28/10 188. Boulder of chalcopyrite, malachite and azurite.
- 189. Greenish grey phyllite or greywacke-schist.
- 190. Granophyric granite, boulder.

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- 28/10 192. Granite, aplitic dyke in the schist 189-190.
- 193. Porphyrite, grey, unaltered, fine-grained.
- 194. Granite, type: "Quartz-monzonite", medium-grained, very fresh.
- 195. Porphyrite, dark, basic; dyke in the foregoing.
- 196. Porphyrite, dark, basic.
- 3/11 197. Calc-sinter, recent. (Boulder.)
- 6/11 198. Porphyrite or -tuff, decomposed.
- 7/11 199. » » »
- 200. Porphyrite or -tuff, decomposed, brecciated.
- 201. Porphyrite or -tuff, decomposed.
- 202. Calc-sinter, with enclosed sand grains.
- 9/11 203. Conglomerate, red, with calcareous matrix.
- 11/11 204. Limestone, grey, dense.
- 13/11 205. Limestone, grey, dense.
- 17/11 206. Limestone, reddish-white, finely crystalline.
- 207. Limestone, reddish-white.
- 208. Porphyrite, decomposed.
- 209. Limestone, white, finely crystalline.
- 210. Black phyllite (boulder).
- 18/11 211. Limestone, dense, yellowish grey.
- 19/11 212. Limestone, finely crystalline, reddish white.
- 213. Limestone, finely crystalline, white.
- 214. Limestone, finely crystalline, reddish white.
- 215. Limestone, finely crystalline, reddish white.
- 216. Phyllite, hard.
- 20/11 217. Limestone, dark, bituminous, finely crystalline.
- 25/11 218. Missing.
- 219. Limestone, dense, dark.
- 26/11 220. » » »
- 27/11 221. » » »
- 222. » » »
- 28/11 223. » » » , brecciated.
- 224. Limestone, finely crystalline, white.
- 30/11 225. » » » , grey.
- 226. » » »
- 227. Very schistose porphyry (?), decomposed.
- 228. Calcite, probably from veins.
- 229. Limestone, finely crystalline, grey.
- 1/12 230. » dense, dark.
- 231. Calcite = 228.

1901.	1901.
<sup>1/12</sup> 232. Calcite = 228.	<sup>12/12</sup> 260. Talc-schist, with siderite.
233. Porphyrite-tuff.	261. Weathered yellow rock.
234. Green phyllitic schist in alternate bedding with:	<sup>13/12</sup> 262. Phyllite.
235. Limestone, finely crystalline, brownish.	263. Vein-quartz.
236. Limestone, crystalline, white.	<sup>14/12</sup> 264. Calc-sinter.
<sup>2/12</sup> 237. Calcareous slate.	265. Greywacke-slate, hard, dark grey.
238. Limestone, dark.	266. Limestone, crystalline, white.
239. Biotite-plagioclase-granite, fresh.	267. Granite, medium-grained, grey, fresh.
240. Phyllite, black.	268. Greywacke-slate = 265.
241. Greywacke, dark, phyllitic.	<sup>14/12</sup> 269. Phyllite, dark-green.
242. Phyllite.	270. » »
<sup>3/12</sup> 243. »	271. Weathered schist.
244. »	<sup>15/12</sup> 272. Mica-schist, dark, fine-grained, with garnet.
<sup>4/12</sup> 245. » (like 241).	273. Dolomite, finely crystalline, schistose.
246. »	274. Vein-quartz, red (boulder).
<sup>10/12</sup> 247. Greenstone-schist, apparently connected with the phyllites.	<sup>16/12</sup> 275. Mica-schist, dark, fine-grained.
<sup>10/12</sup> 248. Sericite-schist, apparently connected with the phyllites.	276. Vein-quartz.
249. Talc-schist with siderite.	277. Quartz-monzonite = 194 (boulder).
250. » » quartz veins.	278. Dolomite, crystalline, white.
<sup>11/12</sup> 251. Calc-sinter-conglomerate, recent.	279. Limestone, coarsely crystalline, white.
252. Greenstone-schist = 247.	280. Dolomite, crystalline, white.
253. Phyllite.	281. Phyllite.
254. Very schistose quartz-porphyry.	282. Hornblende-schist (boulder).
<sup>12/12</sup> 255. »	<sup>17/12</sup> 283. Granite (white soda-granite).
256. »	284. » »
257. »	285. » » gneissic.
258. »	286. Hornblende-biotite-rock, apparently basic inclusion in the preceding.
259. » decomposed.	287. Mica schist, hornblende-bearing.

### Profile from Leh to Kargalik 1902.

1902.	1902.
<sup>11/4</sup> a. Granite, schistose, white; »soda-granite».	<sup>10/4</sup> o. Limestone, dolomitic, finely crystalline, light-grey.
b. » » , reddish grey, »	<sup>11/4</sup> p. Calcite, coarsely crystalline, probably from veins.
c. » » , grey; »	q. Dolomite, finely crystalline, white.
<sup>13/4</sup> d. » » » »	r. Limestone, dense, yellowish.
<sup>14/4</sup> e. » » , white; »	s. » » , grey.
<sup>15/4</sup> f. Dolomite, grey, almost dense.	<sup>13/4</sup> t. » » , bituminous, dark.
g. Dolomite, white, crystalline.	<sup>14/4</sup> u. Black phyllite.
<sup>16/4</sup> h. Hornblende-granite.	v. Limestone, dense, brown.
<sup>17/4</sup> i. Granite, grey, = B: 267.	w. Limestone, finely crystalline, light grey.
<sup>18/4</sup> j. Quartz-diorite, fine-grained.	<sup>19/4</sup> x. Limestone, finely crystalline, light grey, crushed.
k. Greywacke-slate, hard, black.	y. Limestone, impure, schistose, grey.
<sup>19/4</sup> l. Granite, light, weathered.	<sup>20/4</sup> z. Greywacke (?) schistose, weathered.
m. Actinolite-zoisite-quartz-rock, close-grained.	
n. Limestone, dense, dark.	

## 1902.

- $\frac{26}{4}$  a. Phyllite, hard, black.
- $\frac{28}{4}$  a. Sericite-schist, probably strongly schistose granite.
- $\frac{29}{4}$  ö. Gneiss, light grey, probably strongly schistose granite.
- $\frac{2}{5}$  a'. Quartz, granular, white with dark strings.
- b'. Granite, medium-grained, light grey.
- c'.    » , fine-grained,    »    »
- d'.    » , medium-grained, schistose, darker.
- $\frac{2}{5}$  e'.    » , coarse grained, non-schistose, light.

## 1902.

- $\frac{2}{5}$  f'. Mica-schist or strongly schistose granite.
- $\frac{3}{5}$  g'.    »    »    »
- h'. Quartz, granular (= a') and black schist.
- $\frac{4}{5}$  i'. Crushed pegmatite or coarsely crystalline granite.
- j'. Greywacke, fine-grained, dark, typical.
- $\frac{5}{5}$  k'. Mica-schist or strongly schistose granite, garnet-bearing.
- l'. Missing.
- m'.    »





# Geological Map

of the route of Dr. Sven Hedin in Tibet 1899-1902

compiled by

Hedge Backstrom and Harald Johansson

Scale 1:2000000

## Explanation of colours

Red Sandstone series

Greenish series

Shale and Argillite series

Concretes and Metre Schist series

Concretes and Greenish - Shales

Young Volcanic Rocks

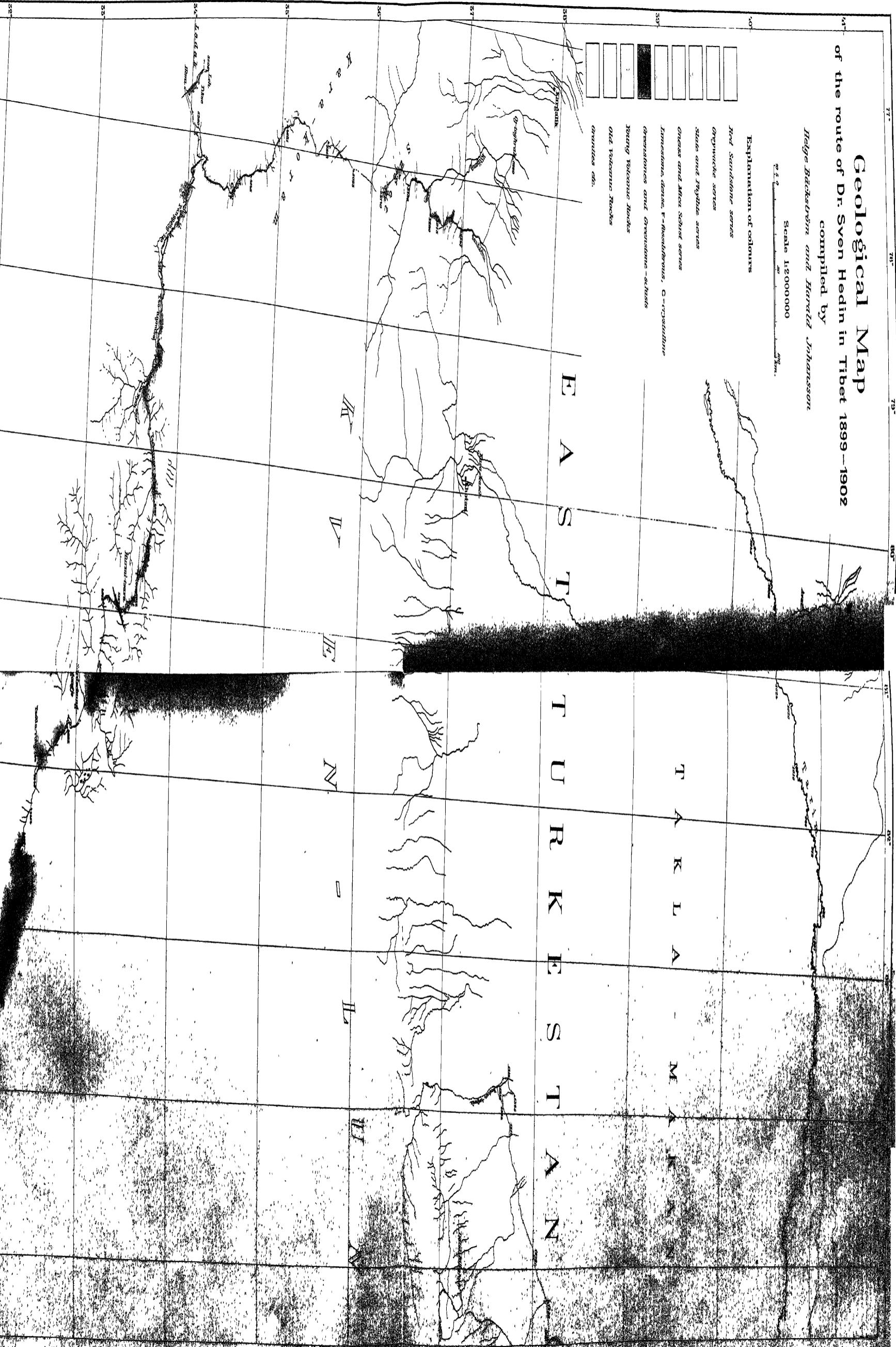
Old Volcanic Rocks

Concretes etc.

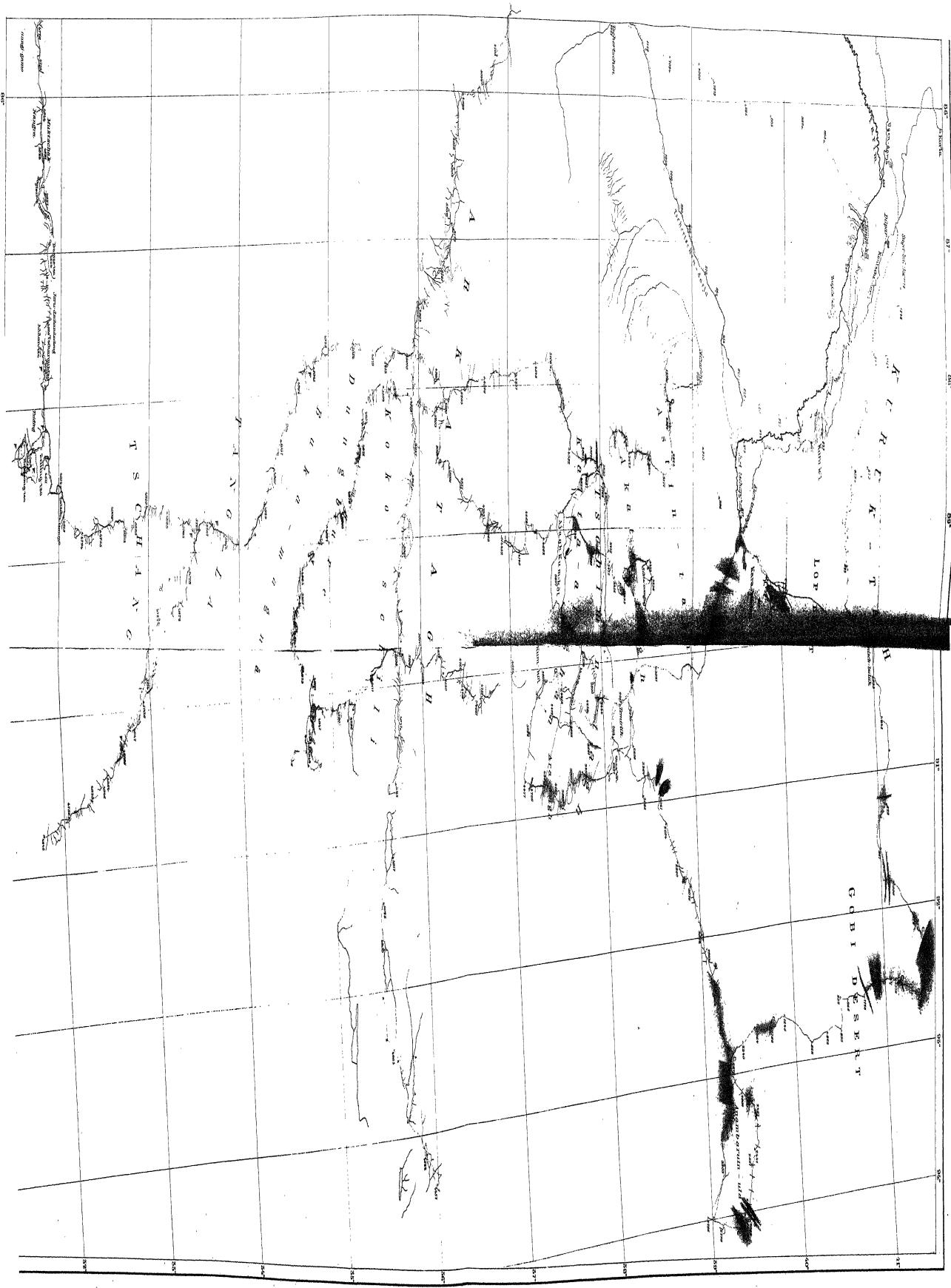
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T A K L A M A N

H I L L      H I L L

















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